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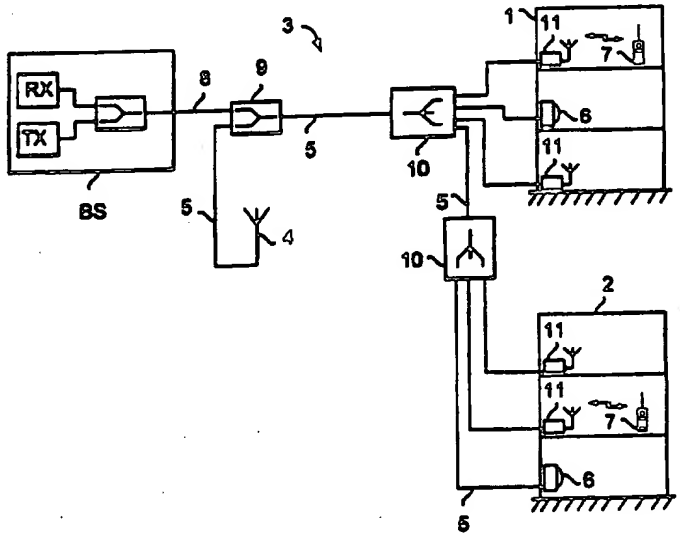

(57) Abstract

This invention relates to a cellular radio system which comprises subscriber units (7), and a base station (BS) comprising a transmitter (TX), a receiver (RX) and means for establishing a telecommunication connection to the subscriber units (7) of the system. In order to improve the audibility of the system, the transmitter (TX) of the base station (BS) comprises means for supplying telecommunication signals to a community antenna system, and the receiver (RX) of the base station comprises means for receiving telecommunication signals transmitted from the community antenna system (3). The system further comprises a repeater (11) which comprises a connection unit (20) for connecting the repeater to the community antenna system (3), and an antenna means for establishing a telecommunication connection to the subscriber unit (7) on radio frequency signals, whereby the repeater (11) is arranged to transmit telecommunication signals between the subscriber unit (7) and the community antenna system (3). The invention also relates to a base station and a repeater.

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Cellular radio system, repeater and base station

The present invention relates to a cellular radio system which comprises: subscriber units, a base station comprising means for establishing a telecommunication connection to the subscriber units of the system, whereby a transmitter of the base station comprises means for supplying telecommunication signals to a community antenna system, and a receiver of the base station comprises means for receiving telecommunication signals transmitted from the community antenna system, and a repeater which comprises a connection unit for connecting the repeater to the community antenna system, and an antenna means for establishing a telecommunication connection to the subscriber unit by radio frequency signals, whereby the repeater is arranged to transmit telecommunication signals between the subscriber unit and the community antenna system. The invention further relates to a repeater for repeating telecommunication signals between a base station of a cellular radio system and a subscriber unit which repeater comprises: a connection unit which comprises means for connecting the repeater to a community antenna system having a signal transmission connection to the base station; an antenna means having a signal transmission connection to the subscriber unit on radio frequency signals; and signal processing means including a first signal processing branch for transferring the signals transmitted by the community antenna system to the radio frequency and for supplying the radio frequency signals via the antenna means to the subscriber unit, and a second signal processing branch for transferring the radio frequency signals received from the antenna means to a predetermined transmission frequency and for

supplying transmission frequency signals further via the connection unit to the community antenna system. The invention also relates to a base station of a cellular radio system which comprises a transmitter arranged to transmit communication signals via a community antenna system to subscriber units, a receiver arranged to receive telecommunication signals transmitted via the community antenna system from the subscriber units.

This invention relates to cellular radio systems, such as the GSM system (Groupe Spécial Mobile), and especially to improving the audibility of cellular radio systems in places where the audibility of the base station is weak, such as inside buildings.

There are prior art solutions in which the aim has been to improve the audibility of the cellular radio system inside buildings by arranging a base station inside a building. In addition to its cost, the most significant weakness of this solution is that it is usually very difficult to place a single base station in such a place that its audibility to different parts of the building would be good. Therefore, in most cases the base station can be heard well only in certain parts of the building, for example, in some storeys, whereas in other parts of the building the audibility of the base station is very weak. The high cost of this prior art solution is in part caused by that the base station equipment as such is valuable, in addition to which the installation of the cabling of the base station inside a building, for example, for establishing a transmission connection between the base station and the base station controller, can cause problems and also become expensive.

The object of this invention is to solve the

problem mentioned above and to provide a better solution than before by means of which the audibility of the cellular radio system can be significantly improved in places where the audibility of the base station is weak, such as inside a building, in a considerably less expensive and simple way than in the prior art solutions. This object is achieved with the cellular radio system according to the invention which is characterized in that the repeater comprises means for receiving a predetermined control signal from the base station, mixer means for transferring signals to be repeated supplied by the base station to a radio channel indicated by the control signal, and adjustment means for adjusting the signal level of the radio frequency signals to the level indicated by the control signal.

The expression the community antenna system refers in this context for example to a fixed antenna system transmitting TV and/or radio signals, such as a cable television system or a building-specific community antenna system in a multi-storey building which includes flat-specific connections.

The invention is based on the idea that the coverage area of the base station of the cellular radio system can be expanded in a very simple and easily implementable way by utilizing the cabling present in the community antenna system so that the community antenna system and the repeater to be connected thereto are used for transmitting telecommunication signals between the base station and the subscriber unit. When the base station can also transmit on the control channel to the repeater on which radio channel and on which power level the repeater should at each time repeat the signals it receives, it can be ensured that the signals intended for a specific subscriber unit are

repeated on a traffic channel and power level suitable for the purpose. Therefore, when required, the base station can reduce the power level used by the repeater to such a level that the repeaters utilizing the same traffic channel can be placed closer to one another than before without disturbing one another. The most significant advantages of the cellular radio system of the invention are thus that the audibility of the base station can be improved in any area covered by the community antenna system in which there is a connection of the community antenna system without requiring additional cabling and needing to install a base station inside a building, wherefore the costs will be significantly lower.

The invention further relates to a repeater that can be utilized in the cellular radio system according to the invention. The repeater according to the invention is characterized in that the first signal processing branch comprises means for receiving a predetermined control signal from the base station through the connection unit, mixer means for transferring signals to be repeated received via the connection unit to a radio channel indicated by the control signal, and adjustment means for adjusting the signal level of the radio frequency signals to a level indicated by the control signal.

Since the repeater according to the invention comprises means for changing the frequency of the signals to be repeated, the signals between the base station and the repeater need not be on a radio frequency, but their frequency can be freely selected in accordance with the data transmission channel to be used.

In one preferred embodiment of the repeater according to the invention, the repeater comprises

means for transmitting a control signal indicating the signal level of the received signal to the base station. Therefore, signals with a constant signal level can be used in the signal transmission between the repeater and the base station since the information needed for handover and the like operations about the signal level of the radio signals received from the subscriber unit can be transmitted to the base station on a separate control channel.

In another preferred embodiment of the repeater according to the invention, the repeater comprises means for producing a clock signal from the control signal transmitted from the base station, whereby the repeater will not need a clock of its own for producing the clock signal. Therefore, the price of the repeater will be lower and it is certain that the repeater is correctly synchronized in relation to the base station.

The invention also relates to a base station which can be utilized in the cellular radio system according to the invention. The base station according to the invention is characterized in that the transmitter comprises means for supplying a predetermined control signal to the community antenna system which control signal indicates the radio channel and the transmission power on which the telecommunication signals transmitted by the transmitter should be transmitted via the radio path to the subscriber units.

The preferred embodiments of the cellular radio system, the repeater and the base station according to the invention are disclosed in the appended dependent claims 2, 4 to 5 and 7.

In the following, the invention will be explained in more detail by means of an example with

reference to the accompanying figures, in which

Figure 1 shows a block diagram of a first preferred embodiment of the cellular radio system according to the invention, and

Figure 2 illustrates a first preferred embodiment of the repeater according to the invention,

Figure 3 illustrates a first preferred embodiment of the base station according to the invention.

Figure 1 shows a block diagram of a first preferred embodiment of the cellular radio system according to the invention. Figure 1 illustrates two multi-storey buildings 1 and 2 which are connected to the same community antenna system 3. In the case of Figure 1, an antenna 4 of the community antenna system receives television and/or radio signals transmitted via the radio path and supplies them by means of cables 5 and branching devices 10 to antenna connections in the buildings 1 and 2 to which e.g. TV receivers 6 can be connected. Alternatively, the community antenna system may as a whole comprise a cable network in which case the antenna 4 will not be needed, but the cabling 5 will reach as far as the station broadcasting TV programmes. Transmitters included in the community antenna system, such as filters and amplifiers, are not disclosed in Figure 1.

Telecommunication signals between a base station BS and subscriber units 7 are also transmitted by the community antenna system 3. The base station BS shown in Figure 1 is in other parts as a conventional base station of the GSM system except that its transmitter TX and receiver RX use different frequency channels than normally. These frequency channels will in the following be referred to as transmission frequencies and they have been selected in view of the

data transmission channel to be used. In the case of Figure 1, the data transmission channel consists of a connection cable 8 and a cable 5 of the community antenna system, whereby the frequency channels of the transmitter and the receiver can be between 5 to 50 MHz or 400 to 750 MHz, for example. The frequencies mentioned above, as well as the frequencies shown in Figure 2, are naturally only shown by way of example. The transmission and reception of the same logical channel takes place by utilizing different frequency channels. In addition to the transmitter TX and the receiver RX shown in Figure 1, the base station may have several other conventional transmitters and receivers, that is, operating on radio channels.

The base station BS is connected to the community antenna system 3 by the connection cable 8 and a branching device 9. When needed, the connection cable 8 can be replaced by another data transmission channel, such as a radio link.

Repeaters 11 are connected to the community antenna connections of buildings 1 and 2. The repeaters 11 may be specific for a building, a storey or a flat. The repeaters 11 are connected via the radio path through antennas to the subscriber units 7 of the cellular radio system. Thus the repeaters 11 receive transmission frequency signals transmitted via the community antenna system 3 from the base station, transfer the received signals to radio frequencies and forward them to the subscriber units. Similarly, the repeaters 11 receive radio frequency signals from subscriber units 7, transfer them to the transmission frequency and forward them via the community antenna system 3 to the base station BS.

The repeaters 11 preferably use a very low transmission power when transmitting radio signals to

the subscriber units 7. Therefore, their coverage area is relatively small, whereby radio cells will become small. This makes it possible that, for example, the same radio channels and/or time slots can be used in different storeys of the same building if it is a question of a frequency (FDMA-Frequency Division Multiple Access) and/or time division (TDMA-Time Division Multiple Access) cellular radio system without the repeaters and subscriber units using the same logical channel disturbing one another. This will increase the traffic capacity of the cellular radio system.

Figure 2 illustrates a first preferred embodiment of the repeater according to the invention. The repeater 11 shown in Figure 2 comprises a connection unit 20 for connecting the repeater to the connection of the community antenna system and an antenna ANT by means of which the repeater is in contact with the subscriber units of the cellular radio system.

The transmission frequency signals received from the base station are filtered and supplied to an amplifier 23 in a first signal processing branch 21. The output of the amplifier 23 is connected to a mixer 24 by means of which the signals are transferred to an intermediate frequency for separating a first control signal S1 and signals S2 to be repeated from one another with filters 25 and 26. The control signal S1 is supplied to a control unit 27 which as a response to the control signal S1 produces a clock signal CLK and control signals CH (which transmits the frequency channels) for oscillators 28 and 29, and a control signal TX_LEVEL for adjustment means 30.

The signals S2 to be repeated are supplied from the filter 26 to a mixer 31 that transfers the

signals S2 by means of the oscillator 28 to the radio channel designated by the control signal S1. The radio frequency signals are supplied to the adjustment means 30 with which the signals are amplified (or attenuated) to the signal level that is determined for them by the control signal S1. The amplified signals are supplied from the adjustment means 30 further to the antenna ANT.

The radio frequency signals received from the subscriber units with the antenna ANT are supplied to a second signal processing branch 22 in which the received signals are amplified and supplied to a mixer 32 with which the radio frequency signals are transferred to a predetermined intermediate frequency after which the intermediate frequency signals S4 are filtered.

An AGC amplifier 37 (Automatic Gain Control) takes samples of the filtered signals on the basis of which a control unit 38 produces a control signal S3 indicating the signal level RX_LEVEL of the received signals. As the signals are filtered before the samples are taken, only the signal level of the signals to be repeated will have an effect on the measuring result. An amplifier 37 also amplifies the signals S4 to a predetermined level.

The control signals S3 and S4 are added after which the added signals are transferred with a mixer 33 to a predetermined transmission level and thereafter the transmission frequency signals are amplified (or attenuated) with adjusting means 34 before they are supplied via the connection unit 20 to the base station by using the community antenna system. The control unit 38 controls the adjusting means 34 in such a manner that the signal level of the signals transmitted to the base station through the community antenna system is

constant, and essentially greater than the level of disturbances present in the cable of the community antenna system.

Figure 3 illustrates a first preferred embodiment of the base station according to the invention. The block diagram of Figure 3 shows the base station BS shown in Figure 1 in more detail, the base station being connected through the cable 8 to the community antenna system. The transmitter TX and the receiver RX do not in the case of Figure 3 transmit radio frequency signals, but frequency channels, which are illustrated in Figure 3 by way of example, are selected for them as being suitable to be employed in the community antenna system.

The signals to be received transmitted via the cable 8 are separated by a duplex filter 40 from the signals to be transmitted. After this, the signals to be received are supplied via a preamplifier 41 of the receiver RX to a mixer means 41 which is responsive to a local oscillator 43 and with which the signals are transferred to a predetermined intermediate frequency. The intermediate frequency signals are channel filtered with filters 44 and 45 after which the signals are detected, decoded, etc. in a manner known per se.

The receiver RX in Figure 3 thus comprises two outputs 46 and 47. A signal S4 is received from the output 46, that is, a signal related to the ongoing telecommunication connections (speech, etc.). A control signal is received from the output 47 by means of which the base station calculates the signal level of the received signal (RSSI-Received Signal Strength Indication), for example. Said information is used for operation connected to handovers, for example. By means of the control signal S3, various alarms are also preferably transmitted to the base station, e.g.

concerning malfunctions in the repeater connected to the community antenna system.

Correspondingly, the base station shown in Figure 3 comprises two inputs 56 and 57. A payload signal S2 (speech, etc.) related to telecommunication connections is supplied to the input 56. A control signal S1 is supplied to the input 57 with which signal information concerning the transmission level, the radio channel (CH) and a clock signal (CLK) is transmitted to the repeater. The payload signal S2 and similarly, the control signal S3 are encoded and modulated after which the signals are mixed up separately with a mixer 52 by using a local oscillator 53. After this, the signals S1 and S2 are amplified with a mutual power amplifier and the amplified signals are supplied via the duplex filter 40 to the cable 8.

It is to be understood that the above specification and the figures related thereto are only intended to illustrate the present invention. Therefore the utilization of the repeater according to the invention is not restricted inside buildings, but it can of course be used anywhere where there is a connection to a community antenna system. The different variations and modifications of the invention will be apparent to those skilled in the art without deviating from the scope and spirit of the invention presented in the appended claims.

Claims

1. A cellular radio system which comprises:

subscriber units (7),

a base station (BS) comprising means for establishing a telecommunication connection to the subscriber units (7) of the system, whereby a transmitter (TX) of the base station (BS) comprises means for supplying telecommunication signals to a community antenna system, and a receiver (RX) of the base station comprises means for receiving telecommunication signals transmitted from the community antenna system (3), and

a repeater (11) which comprises a connection unit (20) for connecting the repeater to the community antenna system (3), and an antenna means (ANT) for establishing a telecommunication connection to the subscriber unit (7) by radio frequency signals, whereby the repeater (11) is arranged to transmit telecommunication signals between the subscriber unit (7) and the community antenna system (3), c h a r a c t e r i z e d in that

the repeater comprises means (26, 27) for receiving a predetermined control signal (S1) from the base station (BS),

mixer means (28, 31) for transferring signals (S2) to be repeated supplied by the base station to a radio channel indicated by the control signal (S1), and

adjustment means (30) for adjusting the signal level of the radio frequency signals (S2) to the level indicated by the control signal (S1).

2. A system according to claim 1, c h a r a c t e r i z e d in that the repeater comprises signal processing means (28, 31, 33) for transferring transmission frequency signals received from the

community antenna system (3) to the radio frequency before they are forwarded to the antenna means (ANT), and for transferring the radio frequency signals received with the antenna means to the transmission frequency before they are forwarded to the community antenna system (3).

3. A repeater for repeating telecommunication signals between a base station (BS) of a cellular radio system and a subscriber unit which repeater comprises:

a connection unit (20) which comprises means for connecting the repeater to a community antenna system (3) having a signal transmission connection to the base station (BS);

an antenna means (ANT) having a signal transmission connection to the subscriber unit (7) on radio frequency signals; and

signal processing means including a first signal processing branch (21) for transferring the signals transmitted by the community antenna system (3) to the radio frequency and for supplying radio frequency signals via the antenna means (ANT) to the subscriber unit (7), and a second signal processing branch (22) for transferring the radio frequency signals received from the antenna means (ANT) to a predetermined transmission frequency and for supplying transmission frequency signals further via the connection unit (20) to the community antenna system (3) c h a r a c t e r i z e d in that

the first signal processing branch comprises means (26, 27) for receiving a predetermined control signal (S1) from the base station through the connection unit (20),

mixer means (28, 31) for transferring signals (S2) to be repeated received via the connection unit (20) to the radio channel indicated by the control

signal (S1), and

adjustment means (30) for adjusting the signal level of the radio frequency signals (S2) to a level indicated by the control signal (S1).

4. A repeater according to claim 3, c h a r a c t e r i z e d in

that the first signal processing branch (21) comprises signal processing means (24, 25, 26, 28) for separating the control signal (S1) from the signals received from the base station via the connection unit; and

that the second signal processing branch (22) comprises: second signal processing means (37, 38) for measuring the signal level of the signals transmitted from the subscriber unit via the antenna means and for producing a second control signal (S3) indicating the measuring result; second mixer means (33) for transferring signals (S4) received from the subscriber unit and the second control signal (S3) to a predetermined transmission frequency; and second adjustment means for adjusting the signal level of the transmission frequency signals to a predetermined level.

5. A repeater according to claim 4, c h a r a c t e r i z e d in that the repeater (11) comprises means (27) for producing a clock signal (CLK) from the first control signal (S1).

6. A base station (BS) of a cellular radio system which comprises

a transmitter (TX) arranged to transmit telecommunication signals (S2) via a community antenna system (3) to subscriber units (7),

a receiver (RX) arranged to receive telecommunication signals (S4) transmitted via the community antenna system (3) from the subscriber units

(7), characterized in that

the transmitter (TX) comprises means for supplying a predetermined control signal (S1) to the community antenna system (3) which control signal (S1) indicates the radio channel (CH) and the transmission power (TX_LEVEL) on which the telecommunication signals (S2) transmitted by the transmitter (TX) should be transmitted via the radio path to the subscriber units (7).

7. A base station according to claim 6, characterized in that the base station (BS) comprises means for receiving a second control signal (S3) transmitted from the community antenna system (3), and for calculating the signal level of the received signal for signals (S4) received with the receiver (RX) on the basis of said second control signal (S3).

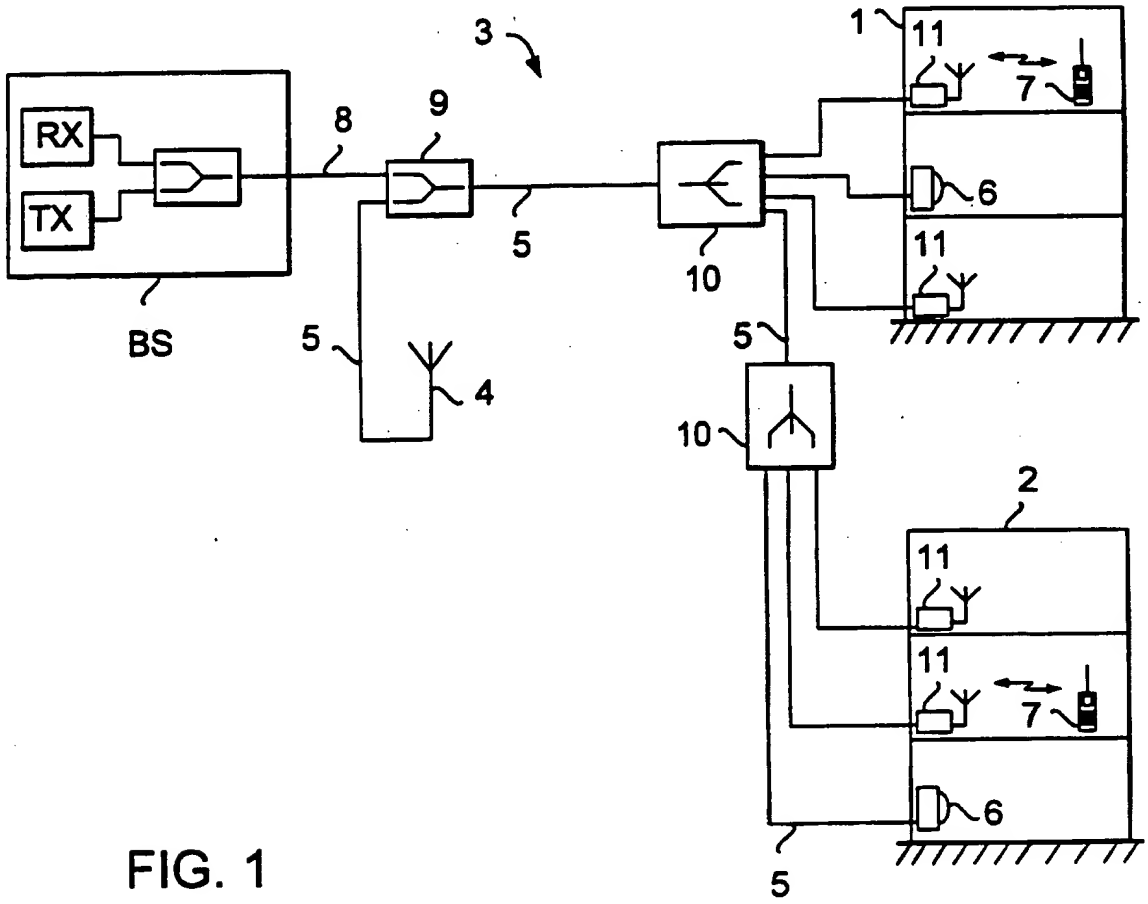
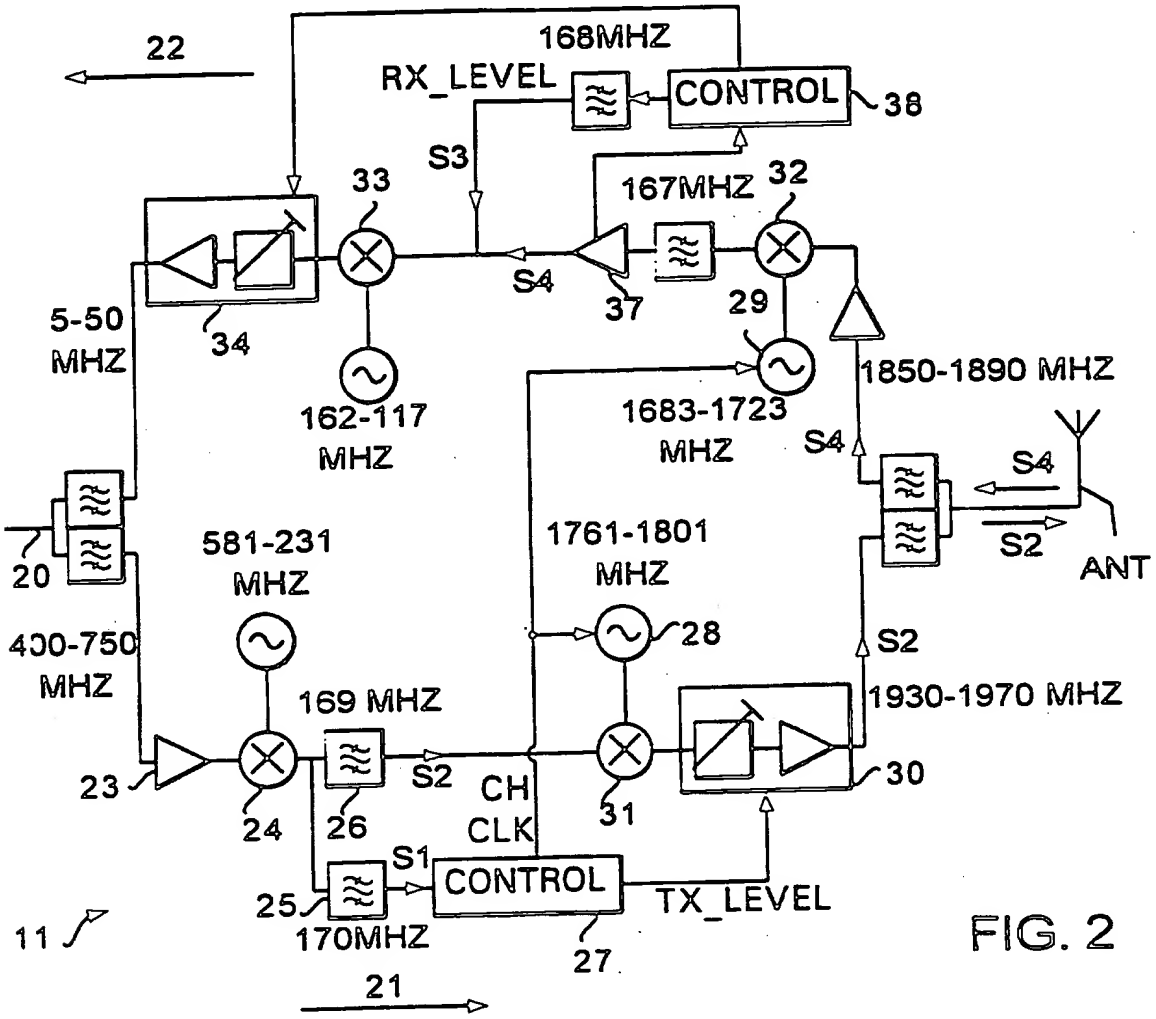


FIG. 1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CONTROL
38
S3
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S4
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5-50
MHZ
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162-117
MHZ
1683-1723
MHZ
1850-1890 MHZ
S4
S4
S2
ANT
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MHZ
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MHZ
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MHZ
28
S2
169 MHZ
1930-1970 MHZ
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S2
CH
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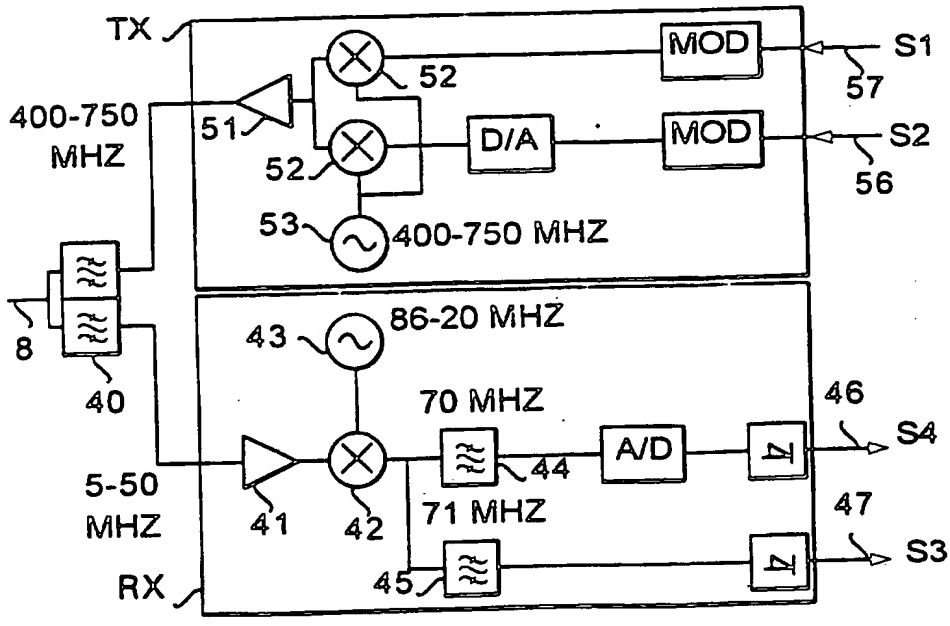
CONTROL
TX_LEVEL
25
170MHZ
27
11
21

FIG. 2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MOD
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52
57
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MHZ
51
D/A
MOD
S2
52
56
53
400-750 MHZ
8
40
43
86-20 MHZ
70 MHZ
46
S4
A/D
5-50
MHZ
41
42
44
71 MHZ
47
S3
RX
45

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 96/00050

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 7/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4745632 A (A.G. DUFFY), 17 May 1988 (17.05.88), column 1, line 1 - column 3, line 12, abstract --	1-7
A	EP 0526285 A2 (CABLE TELEVISION LABORATORIES INC.), 3 February 1993 (03.02.93), figure 1, abstract --	1-7
A	EP 0482503 A2 (KABUSHIKI KAISHA TOSHIBA), 29 April 1992 (29.04.92), figure 6, abstract --	1-7

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 June 1996	18 -06- 1996
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Mikael Sollerhed Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/04/96

International application No.
PCT/FI 96/00050

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4745632	17/05/88	NONE	
EP-A2- 0526285	03/02/93	CA-A- 2067637	30/01/93
		JP-A- 6098046	08/04/94
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EP-A2- 0482503	29/04/92	CA-A,C- 2053670	19/04/92
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		US-A- 5276686	04/01/94